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SUCCESSIVE CHANGES OF THE VERTICAL DISTRIBUTION OF *AIDANOSAGITTA DELICATA* (TOKIOKA) AT A FIXED STATION IN A COVE OF TANABE BAY[1)]

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With Three Text-figures

It is well known that many plankton animals having any kind of effective photoreceptor exhibit the day and night vertical migration. This migration, called the diurnal or diel migration, is generally displayed most pronouncedly in larger and more active animals, but much less remarkably in smaller ones in which the migratory distance must be insignificant, because their swimming power is absolutely very small. Thus, the smaller plankton animals are apt to remain near the sea surface throughout the day and night. The chaetognaths also exhibit a well defined diel migration, as they are provided with a pair of very effective eyes on the dorsal side of the head. This is well known in some oceanic species such as *Parasagitta elegans* (VERRILL) (RUSSEL, 1931). In the neritic species, MURAKAMI (1959) reports that *Aidanosagitta crassa* f. *naikaiensis* (TOKIOKA) will sink down and remain among the thicket of sea weeds in the daytime in some inlets of the Inland Sea of Japan. The same chaetognath is said to be found sometimes condensed near the sea floor in some parts of the Inland Sea (personal information by Dr. Sh. FUSE). *Aidanosagitta delicata* (TOKIOKA) is the smallest species in the Japanese waters and lives limitedly in some inlets or coves on the Pacific coasts from the middle of Honsyu Island to Kyushu Island. It is found very commonly and densely in the coves of Tanabe Bay (FUKUMA and SHIMIZU, 1966). As this species is very small (6.4 mm long at the maximum), it is very questionable that it performs any migration of a very significant scale. However, even a slight vertical migration may it be, it will be very effectual in the turbid water of the inner part of Tanabe Bay. For this reason, it has been a matter of interest to know whether or not the species does the diel migration.

During my ten-day stay at Seto in the summer of 1969, I made a series of continual observations for 24 hours of the vertical distribution of *A. delicata* at a fixed station in a cove of Tanabe Bay in a hope to find some clue to learn the diel migration of this chaetognath. The data obtained seem evidently insufficient to show the diel mig-

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Fig. 2. Number of individuals classified into five size ranges in each haul at respective observations. Raw data in figures and graphs.

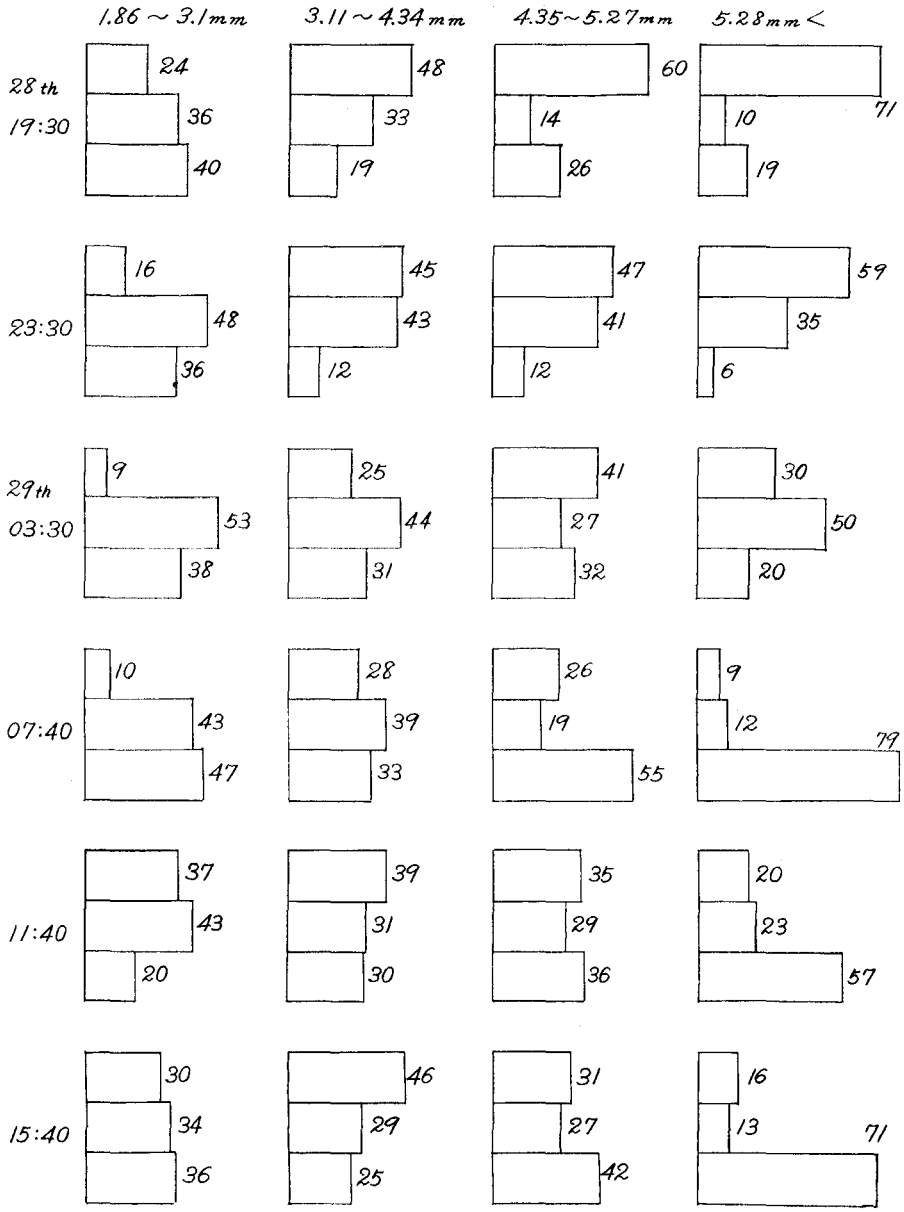

Fig. 3. Individuals of respective size ranges in each water layer at respective observations, represented in percent to the total individuals of the same size range caught throughout the water column from the surface to 12 m at the same observation.

the surface to 14 m deep, in which 4 m-0 m, 8 m-4 m, and 14 m-8 m vertical hauls were made, is given in Table 1. The whole individuals in each haul at respective time of observation, represented in percentage to the total individuals throughout respective series of three hauls, are given in Table 2. The similar representations in the size range from 4.34 mm to the maximal body length are given in Table 3. The individuals of respective size ranges in each water layer at respective observations, represented in percentage to the total individuals of the same size range caught throughout the water column from the surface to 12 m at the same observation, are given in both figures and graphs in Fig. 3. In this text-figure, the number of individuals in the bottom layer 14 m to 8 m is converted mathematically into the number of individuals held in the layer 12 m to 8 m in order to make the comparison between respective layers easier.

Discussions

To the eye rather in expectation of obtaining some evidence of the diel migration in *A. delicata*, the number of individuals may seem superficially larger in the surface layer than in the bottom layer at three observations (19h:30 and 23h:30 on 28th, 19h:40 on 29th) made in the dark time, but smaller in the surface layer than in the bottom layer at other observations made mostly in the daytime (Table 2). As the diel migration is generally less remarkable in young smaller individuals, this trend seems to be shown more clearly in Table 3 in which young individuals smaller than 4.34 mm in body length are excluded. Further, the trend in larger individuals is seemingly seen again markedly, when the successive changes of the vertical distribution are traced in respective size ranges (fig. 3).

In discussing the vertical migration, however, it is essential to see whether the successive observations were made in the same water mass holding the population of a certain stable age composition, or to learn if a certain age composition was maintained steadily throughout the wide range being under the influence of tidal flows. Both of the above-mentioned points seem to be negative, as two rather sudden changes of the age composition were observed (Table 1). The one was the remarkable decrease of the proportion of the smallest size range (1.86 mm–3.1 mm) between 03h:30 and 07h:40 on 29th and the other was of the larger size ranges between 19h:30 and 23h:30 on 28th. Moreover, there was a sudden increase of the total individuals throughout the water column from the surface to 14 m between 23h:30 on 28th and 03h:30 on 29th (fig. 2). The individuals in the bottom layer seemes increased very sharply between 03h:30 and 07h:40 on 29th. In the darkness of 03h:30 on 29th, the individuals were fewer in the surface layer than in deeper layers. Comparing the graphs in Fig. 2 carefully one another, it may be concluded safely that the changes found in the vertical distribution in respective size ranges were hardly brought about by the vertical migration of individuals belonging to the same population. Rather, it is very probable that the

displacement of water will occur with tidal phases very complicatedly and differently in respective layers, and thus the influx of the bottom water containing a dense population of this chaetognath, especially of larger size, into the lower layer of the fixed station occurred between 03h:30 and 07h:40 on 29th. A remarkable change of population density of this chaetognath with tides is already shown by TOKIOKA (1951, p. 18) in a cove of Ago Bay on the east coast of Kii Peninsula.

Nevertheless, it can never be concluded that the diel migration is not found even in larger individuals of *A. delicata.* Generally saying, the predominancy of larger individuals in deeper layers, in other words the vertical migration with age, seems existing, although in some water columns larger individuals may be more abundant in surface layers than in the bottom layer even in the daytime as noted already by FUKUMA and SHIMIZU (1966).

It is natural that the satisfactory analyzation for the diel migration is very difficult in the area which is affected complicatedly by the water movements with tide. Simultaneous observations at a number of stations adequately distributed, including some hydrological observations, or a long-term continuous observations at least for several days at a fixed station, also inclusive of some hydrological observations, are necessary to define the diel migration of this chaetognath definitely.

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